PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G07D 7/00	A1	(11) International Publication Number: WO 91/08556 (43) International Publication Date: 13 June 1991 (13.06.91)

(21) International Application Number: PCT/GB90/01809

(22) International Filing Date: 23 November 1990 (23.11.90)

(30) Priority data:
8926654.8 24 November 1989 (24.11.89) GB

(71) Applicant *(for all designated States except US):* PRICE STERN SLOAN, INC. [US/US]; 360 North La Cienega Boulevard, Los Angeles, CA 90048 (US).

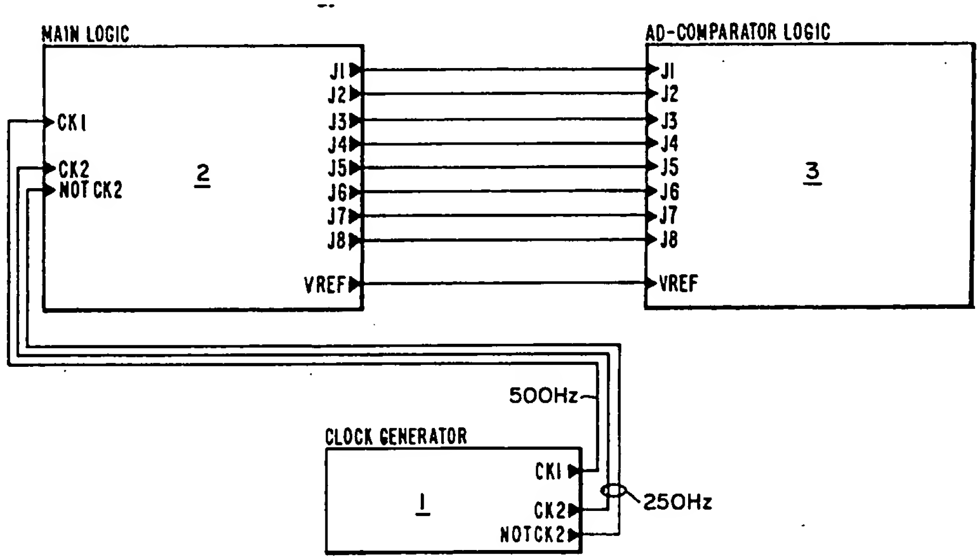
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : MUNFORD, John, Roy [GB/GB]; 49 Willoughby Drive, Empingham, Rutland, Leicestershire LE15 8PY (GB).

(74) Agent: GALLAFENT & CO.; 8 Staple Inn, London WC1V 7QH (GB).

(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.

(54) Title: SECURITY PRINT DETECTORS



(57) Abstract

A method and apparatus are disclosed for detecting the presence of a narrow band infrared absorptive material. Such materials are highly unusual and may be incorporated into inks or coatings for use in security printing applications. By illuminating an article bearing a coating with light alternately in the narrow band absorption region and outside that region, and by processing signals representative of the reflected intensity at the two different wavelengths, conclusions may be arrived at as to the presence or otherwise of the narrow band infrared absorptive material, even when broadband infrared absorptive material such as carbon black or other pigments is present in the coating, ink or the like.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	ML	Mali
AU	Australia	FR	France	MN	Mongolia
BB	Barbados	GA	Gabon	MR	Mauritania
BE	Belgium	GB	United Kingdom	MW	Malawi
BF	Burkina Faso	GN	Guinea	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	SD	Sudan
CF	Central African Republic	KP	Democratic People's Republic of Korea	SE	Sweden
CG	Congo			SN	Senegal
CH	Switzerland	KR	Republic of Korea	SU	Soviet Union
CI	Côte d'Ivoire	LI	Liechtenstein	TD	Chad
CM	Cameroon	LK	Sri Lanka	TG	Togo
DE	Germany	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		
ES	Spain	MG	Madagascar		

SECURITY PRINT DETECTORS

This specification relates to security print detectors.

There is a wide variety of occasions where it is desired rapidly to check the authenticity of a document. The document may be one of monetary value such as a bank note or cheque or may be for example a label, admission ticket or the like. In order to be able to detect attempts at forgeries or other fraudulent activity, it has long been appreciated that this may be done by providing suitable printing in association with suitable detection apparatus. However, many systems proposed in the past have been complex and in particular have required substantial apparatus for authenticity checking. There are many situations where such outlay is unjustified and it is, in any event, desirable to make both the printing of the item in question and the discrimination between genuinely printed articles and attempts at forgery or counterfeit as simple and inexpensive as possible.

A widely proposed approach involves the use in the print of materials which are not detectable to the naked eye but which nevertheless have optical properties which can be detected using appropriate apparatus. Thus many systems have been proposed relying for their operation on the presence in the print of materials which, under

illumination with light of an appropriate wavelength but outside the visible region of the spectrum, react in a detectable way. Fluorescent or phosphorescent materials have been widely suggested. A classic approach to security marking has been to provide a marking which is invisible to the naked eye but which becomes visible under stimulation of ultra-violet irradiation by radiating in the visible region of the spectrum. Simple visual inspection of the item in question under such UV irradiation can be a satisfactory simple means of detecting counterfeit or forged articles.

Equally, articles relying on fluorescence or phosphorescence, where the emitted radiation under UV irradiation is in the visible region of the spectrum, are easily identifiable has having such properties, thus giving the would-be counterfeiter or forger a head start.

Broad band infra-red absorbent materials have also been used in the security field to provide a degree of authenticity to an article. Materials have also been developed which show narrow band absorption of particular wavelengths within the infra-red spectrum, and their use in security printing has been suggested. The use of these latter narrow band IR absorbers, however, presents a particular problem, since broad band infra-red absorbent materials (of which carbon black is the most common) also absorb IR radiation in the narrow band area of spectrum being illuminated to a similar degree to that absorbed by the narrow band materials themselves.

The problem underlying the invention is to provide a method of unambiguously detecting the presence of such narrow band absorbers, even in the presence of broadband absorbers, or other infrared absorptive pigments, e.g. phthalocyanine pigments.

In accordance with the invention, this is achieved by an inspection of the absorption of the item under test in at least one spectral area adjacent to and below the area in which the narrow band absorber absorbs as well as in the narrow band itself, and time division multiplexing of the detected signal to enable a comparing of absorption at the two areas to be made and a decision or authenticity made on the basis of that comparison.

According to the present invention, there is provided a method of detecting the presence or absence of a narrow band IR absorbent material on a substrate which comprises alternately illuminating the substrate with infra-red radiation inside and outside the narrow band and comparing the reflected signals. If a narrow band absorber is present, they will vary, even if there are other materials present. A single detector may look at the reflected IR radiation, the signal therefrom being time division multiplexed and thereafter processed to enable the presence of narrow band absorptive material to be unambiguously determined.

According to a further feature of the invention there is provided apparatus for detecting the presence or absence of narrow band infra-red absorbent material on an article which comprises means for alternately illuminating the article with infra-red radiation of two (or more) different wavelengths, only one of which is in the narrow band absorption region, detecting the amount of radiation reflected therefrom in synchronous fashion, and using the results of such detection to discriminate between articles having narrow band absorber thereon and articles which do not have such narrow band absorber on them even if they have broadband absorber thereon.

Such apparatus may be designed to carry out detection of

the narrow band IR absorptive material in a variety of different contexts. For example, the apparatus may be configured as simple handheld apparatus having an emitter/ detector head for placing against the article in question, an actuating switch and something providing a visible or audible indication of whether the narrow band absorbent material is present or not.

Alternatively, the apparatus may be built into processing machinery for articles of a security nature, for example banknotes or cheque processing machinery where it may be arranged to detect the presence of narrow band infrared absorptive material used as a security feature on such items and, for example, to reject automatically any doubtful banknote or document. In such a case, the documents it is desired to test may be sequentially fed past a line of illumination/sensor devices or placed over an array of such devices, the signals being thereafter electronically processed to provide an appropriate comparison.

In either case, the apparatus preferably comprises means for adjusting the intensity of illumination at the two (or more) different wavelengths to be the same or substantially the same and preferably also compensation means are provided to offset any difference in sensitivity of the common detector at the two different wavelengths.

The apparatus may comprise means for ignoring spurious signals picked up by the sensor. Particularly in the case of the detection of narrow band infrared absorbers forming parts of prints on paper substrates, the range of reflected energy can be defined in fairly narrow terms and any sensor input above a given upper threshold or below a given lower threshold may be rejected.

The invention is illustrated by way of example with reference to the accompanying drawings in which:

Figure 1 is a schematic block diagram of a handheld detector

Figure 2 is a circuit diagram of the clock circuit shown in Figure 1

Figure 3 is a component circuit diagram of the main logic circuit block shown in Figure 1 and

Figure 4 is a component circuit diagram of the digital comparator logic and output block shown in Figure 1.

The detector unit is designed for use with printed material where the printing is formed of a medium containing a narrow band infra-red absorbing material. Narrow band infra-red absorbing materials have recently become available in commerce and can be obtained under various trade designations. Such compounds are narrow band infra-red absorbers having a peak absorption response of about 780nm. They are effectively invisible or hardly visible as such, and are organic solvent soluble enabling their easy incorporation into printing inks.

Referring to the drawing, the detector unit consists of a number of basic units which are shown on the diagram as discrete components including a number of integrated circuits. In a commercial unit, the majority of the components would be integrated onto a single custom chip.

Referring to Figure 1, a handheld detector unit for detecting the presence of narrow band infrared absorber has circuitry consisting of three blocks, viz. a clock generator, a main logic board 2 and a digital comparator

logic board 3 connected as shown. The last of these contains two light emitting diodes, one red and one green. The circuit is arranged, when actuated, to light the green light emitting diode when the sensor head described below is placed against a substrate including a narrow band IR absorber, and otherwise to light the red LED.

Referring to Figure 2, this shows a simple clock circuit, fed with an appropriate supply voltage, consisting of a stabilised oscillator circuit 10 providing a 500 Hz output. This is fed into a standard divider chip providing two complementary outputs each at 250 Hz and identified as CK2 and NOTCK2. The 500 Hz output is identified as CK1 and, as shown on Figure 1, these three outputs are fed to the main logic board 2, shown in more detail in Figure 3.

Referring now to Figure 3, this shows in its upper portion a power supply circuit for the item consisting of a battery 20, switch 21 and a voltage regulator 22. Variations in output are smoothed by capacitor 23 and a stabilised five volt supply is fed to the common terminal of a packaged optoelectronic emitter/sensor unit 24.

The unit 24 consists of two infrared emitting diodes and a phototransistor mounted on a common substrate and packaged in a cylindrical infrared light transparent plastics housing. The housing is divided by a partition which is opaque to the radiation emitted by the diodes into two chambers, one which contains the diodes and the other of which contains the phototransistor. The face of the device is polished flat. If the device is held with its face slightly spaced from a surface and one or other of the diodes is stimulated, infrared radiation is emitted from the device, reflects off the surface adjacent it and, in that way, illuminates the phototransistor. The degree

of illumination will depend on the distance of the substrate from the emitter but, more importantly, on whether the surface against which the unit is placed contains narrow band infrared absorptive material or not.

The detector unit shown in the Figures is designed to detect the presence or absence of infrared absorbent material having a narrow absorption band centred on a wavelength of 780nm. In the unit illustrated, one of the LEDs accordingly emits at 780nm, the adjacent one at 710nm.

The LEDs are turned on alternatively via the CK2 and NOTCK2 pulses, and series switching transistors 25. The intensity of the emitted radiation from each is controlled by means of a pair of variable resistors 26 which are adjusted to provide substantially equal outputs from the two light emitting diodes.

The phototransistor forming part of unit 24 has a pair of circuits 30, 31 in series with its emitter. Each circuit consists of a variable resistor in series with a clocked switch, the two clocked switches being clocked by CK2 and NOTCK2 as shown. By adjusting the two variable resistors when illuminating a neutral broadband surface of known absorption characteristics, differences in the spectral sensitivity of the phototransistor at the two wavelengths indicated may be compensated for such that the signal on the emitter of the sensor is intensity dependent rather than intensity and wavelength dependent.

The output on the emitter of the phototransistor is fed to two clock switches 32 and 33, again clocked by CK2 and NOTCK2, and when switched on, switches 32 and 33 allow the signal on the phototransistor emitter to be fed to a sample and hold circuit 34 or 35, which provides a

continuous output voltage to an A/D converter comparator chip 36. The output from sample and hold circuit 35 which corresponds to the 710nm illumination is denoted VREF and is fed to board 3 at an output 38 for purposes described below.

Comparator chip 36 is a standard comparator chip designed to produce an 8 bit parallel output representing the ratio of input signal from sample and hold circuit 35 to input signal from sample and hold circuit 34. In order to enable the proprietary chip to do this, it is clocked at 500 Hz from CK1 by a circuit generally indicated at 40 and provided with a 150 KHz sampling input from an oscillator 41.

The 8 bit parallel output is fed to board 3 which is shown in more detail in Figure 4.

Referring now to Figure 4, this shows a pair of digital comparator chips 50, 51 which act respectively on the four less significant bits and four more significant bits of the 8 bit parallel input. Each compares the input with a fixed reference provided by means of a DIP switch/resistor array 52, 53 respectively. The result of the comparison produced by chip 50 is fed to inputs on chip 51 which is arranged to produce an output only if the 8 bit digital input to the board drops below the 8 bit digital input set by the two DIP switch/resistor arrays 52, 53.

Since the 8 bit input word constitutes the ratio of the absorption at 780nm to absorption at 710nm, by setting the DIP switches appropriately an appropriate threshold may be set indicative of the presence of narrow band infrared absorber. In the absence of any such narrow band infrared absorber, the absorption will be the same, the signals emitted from the phototransistor 24 will be the same and

the 8 bit word put out from board 2 to board 3 will be, in binary notation, 1111 1111 or very close thereto. If the threshold chosen is that the absorption at 780nm must give rise to a reflectance of less than 75 percent of the reflectance at 710nm, then the figure set on the DIP switches will be 1001 1111 and only when the narrow band IR absorber is present will such a difference be detected.

In such circumstances, the comparator circuits 50 and 51 together provide an output circuit 51 which goes low thus turning switching transistor 60, which is in series with the red LED, off. The collector of switching transistor 60 then goes high, thus turning on a switching transistor 61 which is in series with the green LED 62. This thus illuminates, showing that the narrow band infrared absorber is present.

As noted above, the output from sample and hold circuit 35, denoted VREF, is also fed to some analogue comparator logic present on board 3 and indicated generally at 70 in Figure 4. Two operational amplifiers 71 and 72 have VREF applied to their negative and positive inputs respectively, their positive and negative inputs respectively being supplied with a voltage of three volts and one volt. The outputs of operational amplifiers 71 and 72 are both fed to the base of switching transistor 60 so that if the reference voltage is greater than an upper threshold of three volts or less than a lower threshold of one volt, operational amplifier 71 or 72 output drives switching transistor 60 on and lights the red LED, indicating that no narrow band infrared absorber is being detected.

Thus, only in the case of the presence of narrow band infrared absorber will the gr en LED become lit.

Conveniently the entire circuit including the two light emitting diodes and the phototransistor is contained in a suitable pen or wand which has an operational tip which may be pressed into contact with the surface to be tested. Pressing the tip into contact may operate the switch 21 to energise the circuitry shown so that the detector unit when not in use is automatically switched off.

It should be noted that the apparatus does not rely on absolute values for the infrared absorption, but rather on relative values of absorption at a wavelength corresponding to the narrow band absorption of the narrow band absorber and at a separate wavelength spaced from that. Because of the reliance upon a ratio, the absolute absorption values may vary and indeed will vary in practice, dependent upon, in particular, the absorption of the substrate bearing the material under test and the presence of other materials such as broadband infrared absorbers, phthalocyanine pigments or the like in the material under test.

CLAIMS

1. A method of detecting the presence or absence of a narrow band IR absorbent material on a substrate which comprises alternately illuminating the substrate with infrared radiation inside and outside the narrow band and comparing the reflected signals and processing them to derive a decision signal corresponding to the presence or absence of the narrow band IR absorbent material.

2. A method according to Claim 1, wherein the illumination outside the narrow band is illumination of a shorter wavelength than the wavelength of the narrow band.

3. A method according to Claim 1 or 2, wherein the reflected signals are sensed by a single infrared detector element or array of such elements, the output of which is time division multiplexed and thereafter processed.

4. Apparatus for detecting the presence or absence of a narrow band infrared absorbent material on an article which comprises means for illuminating the article alternately with infrared radiation of two (or more) wavelengths, only one of which is in the narrow band absorption region, detecting the amount of radiation relfected therefrom in synchronous fashion and using the results of such detection to discriminate between articles having narrow band absorber thereon and articles which do not have such narrow band absorber thereon.

5. Apparatus according to Claim 4 and including two infrared light emitting diodes and means for adjusting the intensity of emission to match the intensity of emission of each between the two diodes.

6. Apparatus according to Claim 4 or 5 and including a

common infrared sensitive photodetector and synchronous means for varying the output of the photodetector to compensate for differences in spectral sensitivity thereof at the two (or more) different wavelengths.

7. Apparatus according to any one of Claims 4 to 6 and comprising means for generating signals representative of the amount of reflected radiation at the two wavelengths, means for generating a ratio of the amount of reflected radiation in the narrow band relative to the amount of reflected radiation outside it, means for comparing that ratio with a preset value and means for indicating the presence of the narrow band absorber when the ratio falls below the preset ratio.

8. Apparatus according to any one of Claims 4 to 7, wherein the presence of narrow band infrared absorbent material is indicated by a visual indicator.

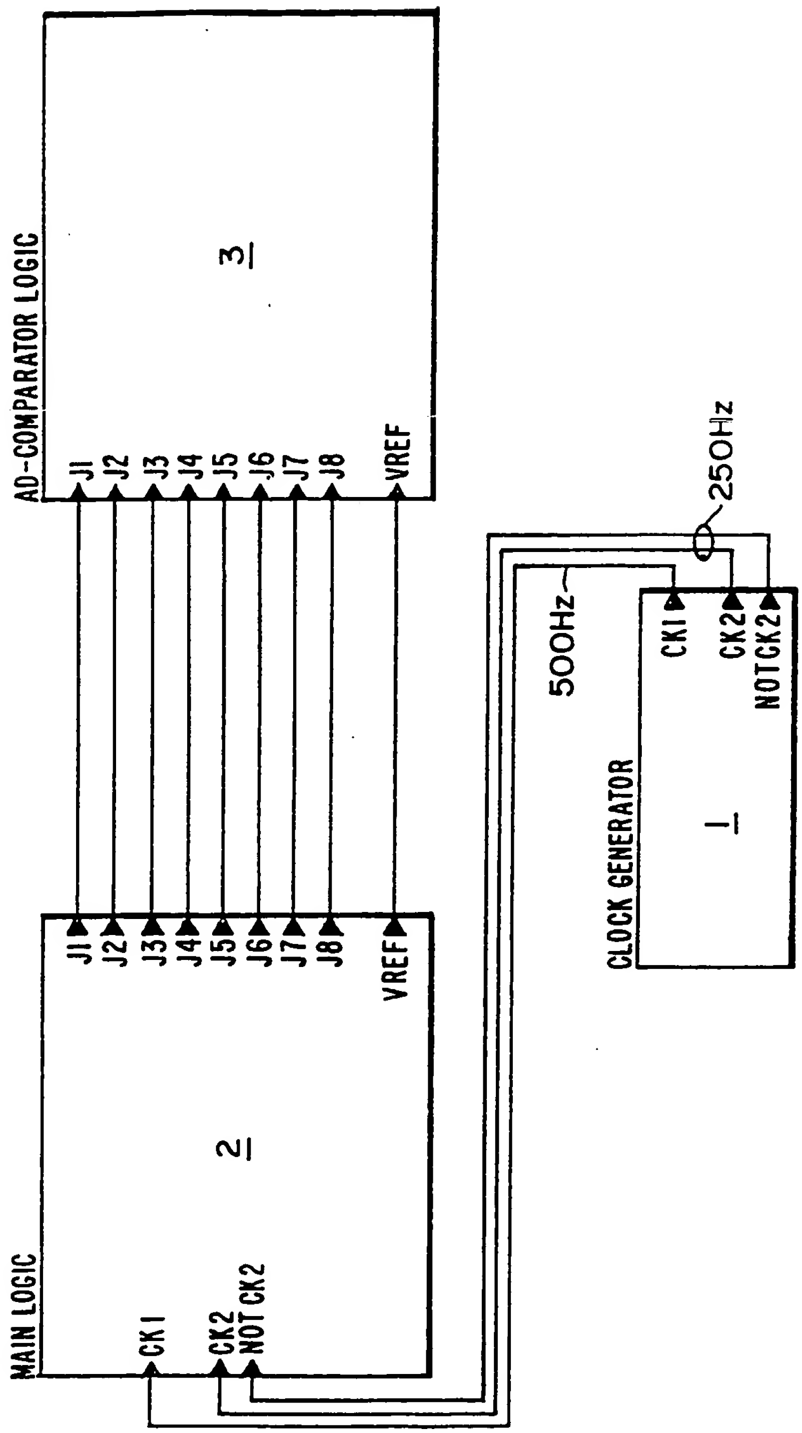

AD-COMPARATOR LOGIC
3
J1
J2
J3
J4
J5
J6
J7
J8
VREF
MAIN LOGIC
2
CK1
CK2
NOT CK2
CLOCK GENERATOR
1
500Hz
250Hz

FIG. 1.

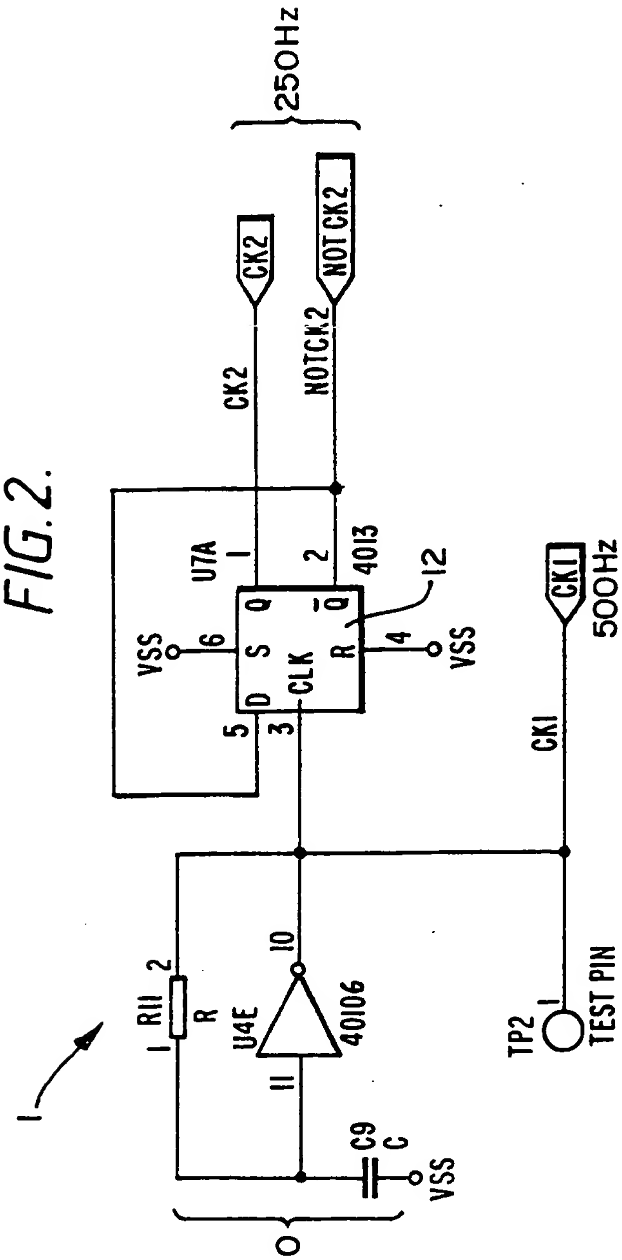

250Hz
CK2
NOT CK2
CK2
NOTCK2
U7A
4013
12
VSS
S
Q
CLK
R
D
VSS
CK1
500Hz
CK1
R11
R
U4E
40106
TP2
TEST PIN
C9
C
VSS
10
1

FIG. 2.

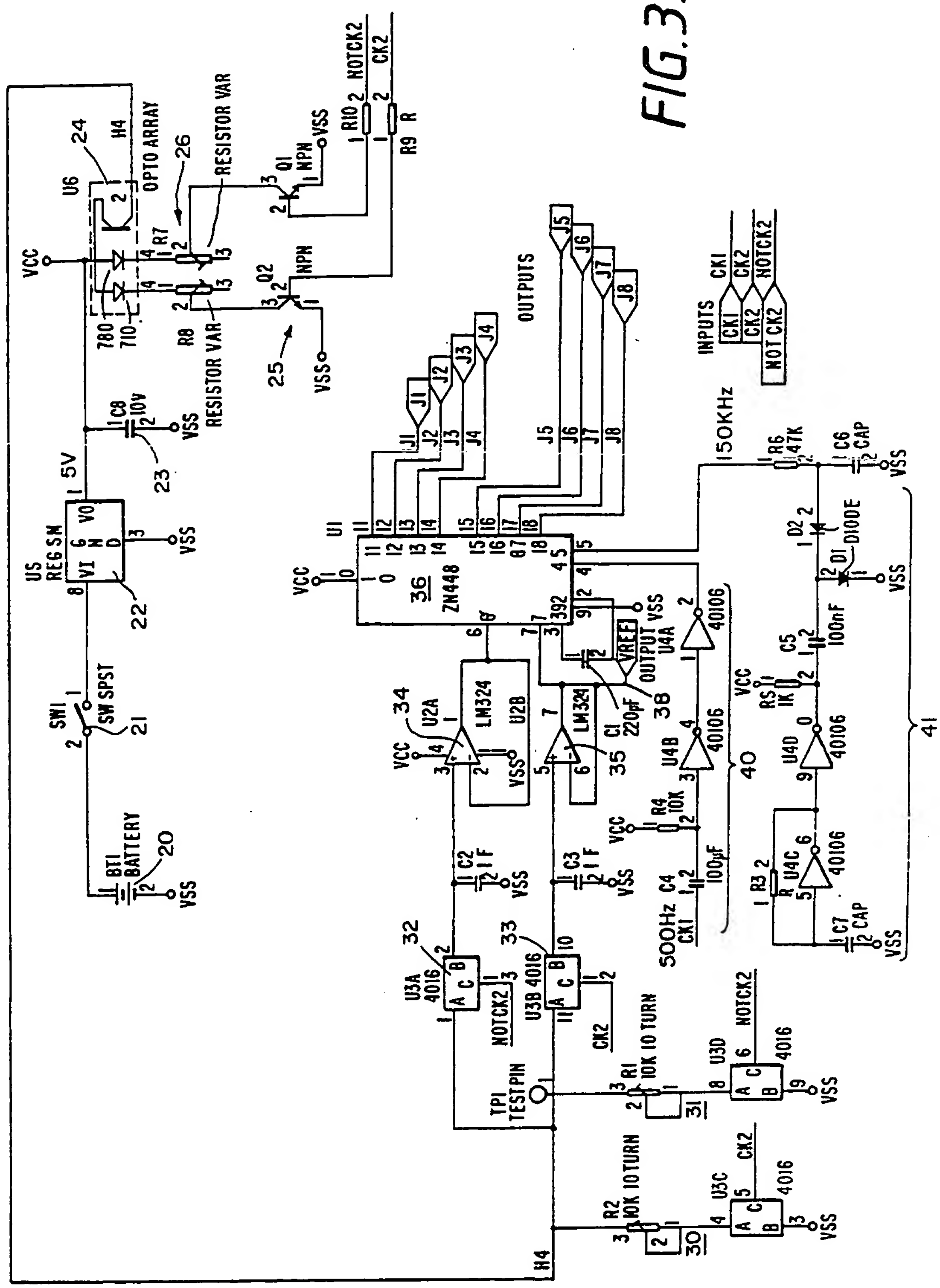

OPTO ARRAY
U6
H4
RESISTOR VAR
NOTCK2
CK2
VCC
VSS
NPN
R10
R9 R
R7
R8
780
710
C8 10v
5V
US REG SM
SW1 SW SPST
BT1 BATTERY
OUTPUTS
INPUTS
CK1
NOT CK2
150KHz
R6 47K
C6 CAP
D2
D1 DIODE
C5 100nF
R5 1K
U1
ZN448
LM324
U2A
U2B
40106
U4A
U4B
U4C
U4D
C1 220pF
VREF
OUTPUT VSS
R4 10K
C4 100μF
500Hz
C2 1 F
C3 1 F
U3A 4016
U3B 4016
U3C
U3D
TP1 TESTPIN
R1 10K 10 TURN
R2 10K 10TURN
C7 CAP
R3 R

FIG.3.

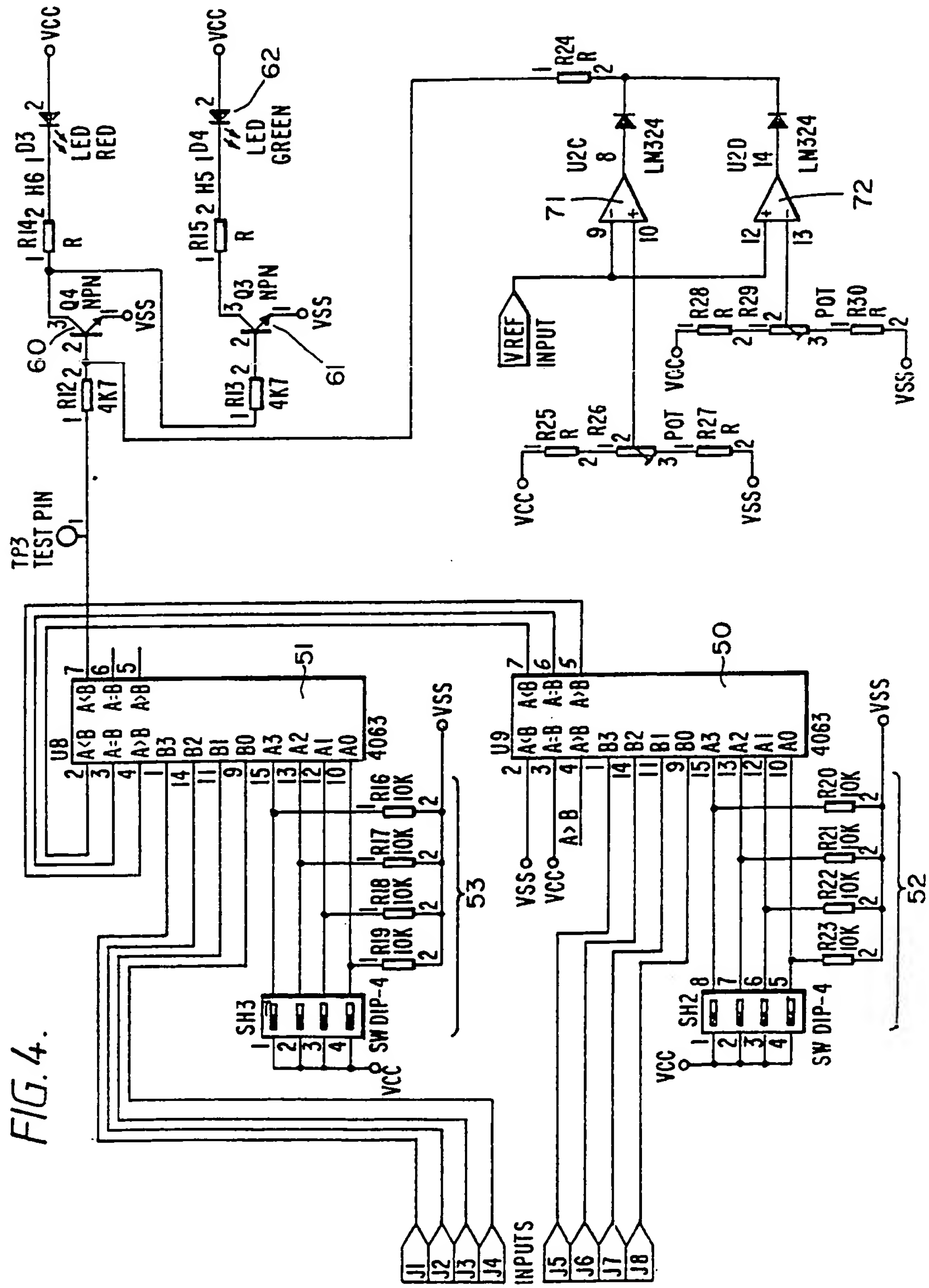

VCC
LED RED
D3
R14
R
Q4 NPN
VSS
60
R12
4K7
LED GREEN
D4
62
R15
Q3 NPN
61
R13
R24
U2C
LM324
71
U2D
72
VREF INPUT
R25
R26
POT
R27
R28
R29
R30
TP3 TEST PIN
U8
51
4063
R16
R17
R18
R19
10K
53
SH3
SW DIP-4
U9
50
A>B
R20
R21
R22
R23
52
SH2
J1
J2
J3
J4
INPUTS
J5
J6
J7
J8

FIG. 4.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01809

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G07D7/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G07D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	EP,A,0092691 (TOSHIBA) 02 November 1983 see abstract see page 8, line 30 - page 9, line 2	1, 4, 7
Y		3, 5, 6

X	EP,A,0314312 (DE LA RUE) 03 May 1989 see abstract see page 2, lines 14 - 22 see page 2, line 50 - page 3, line 5	1, 4, 7

Y	EP,A,0095948 (FUJITSU) 07 December 1983 see abstract see page 5, lines 24 - 33 see page 6, line 19 - page 7, line 21 see page 12, line 8 - page 13, line 12	5
A		1, 2, 6

	-/--	

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25 FEBRUARY 1991	25.03.91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	TACCOEN J-F.P.L.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	EP,A,0125060 (DE LA RUE) 14 November 1984 see abstract see page 5, lines 6 - 19 see page 10, lines 14 - 17 ---	3, 6

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9001809

SA 42120

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 25/02/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0092691	02-11-83	JP-A- 58175091	14-10-83
		US-A- 4524276	18-06-85
EP-A-0314312	03-05-89	JP-A- 1141338	02-06-89
		US-A- 4935628	19-06-90
EP-A-0095948	07-12-83	JP-A- 59176606	06-10-84
		JP-A- 59000604	05-01-84
		JP-A,B,C59014088	24-01-84
		US-A- 4559452	17-12-85
EP-A-0125060	14-11-84	US-A- 4650320	17-03-87

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82